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ABSTRACT

The use of computer simulations as teaching devices in two psychology courses (statistics and research design and physiological psychology) is discussed. In the statistics and design course the primary purpose of simulation activities was to provide a problem and data set which could be used to practice skills acquired through a traditional approach. In the physiological psychology course the simulations provided a means by which students could examine processes and learn to predict the outcome of active processing in a system. Prelimanary evaluation indicates that simulations provide for time effective and higher quality classroom experiences without radically transforming class structure. (Author/STS)

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COMPUTER SIMULATIONS

IN TEACHING PSYCHOLOGY

by

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Computer Simulations in Teaching Psychology

The use of computer simulations as learning devices in two different psychology courses is compared. In one course, statistics and design, WRIST is used to give the student practice with designing experiments and analyzing their results. Simulations serve primarily a support function, providing the students with realistic problems and outcomes for practicing the skills being learned in the course. In a second course, physiological psychology, a set of simulations is used to supplement lecture and reading materials. The models facilitate the learning process through assuring that the student directly explores many principles of nervous system activity, as well as examining the multiple consequences associated with each input parameter change. The discussion focuses on the manner in which educational objectives direct the choice and implementation of simulations in a course of study.

Several authors have described the ways that simulations offer an alternative learning environment that may have advantages over traditional classroom settings (2, 3, 4). However, little discussion has focused on how simulation activities may be integrated into an undergraduate course curriculum. In general, simulations have been used as a substitute for traditional activities such as laboratory exercises (1, 5, 9) and lecture formats (14). This practice has produced a certain amount of polarization among instructors into camps of "simulators" vs "traditionalists," which, if continued, may ultimately prove to have two undesirable consequences for the use and evaluation of simulations in undergraduate courses. First, many instructors are unwilling to engage in a radical change in their methods of presenting information, especially since the heuristic advantage of simulations has not been firmly established. In addition, since simulations are more time-consuming than traditional activitities, their extensive use severely limits the number of topics that may be presented in a semester,

which is problemmatic in many survey-type courses. Second, it is possible that simulations may be more effective when used in conjunction with traditional activities than when used as a primary vehicle for learning in some courses. A more balanced use of these techniques would also help address the problems noted earlier. The present paper describes two attempts to achieve an integration of simulation activities into experimental psychology courses.

Physiological psychology and statistics and design are courses in which a fair amount of straightforward information-transmission is necessary to prepare students to deal with more complex models and concepts. In statistics and design, competence in some areas of algebra, an ability to apply formulas correctly, and a familiarity with a specific vocabulary is needed before one can begin to examine research applications. In physiological psychology, the necessity of a specialized vocabulary is even more apparent, as well as the need for some familiarity with a body of literature that surveys over a dozen topics in physiology and behavior. Since it is generally agreed that traditional methods offer advantages over simulations in meeting these educational objectives (2), it might appear that the use of simulations would be restricted in such courses.

On the other hand, both courses demand that the student understand different models that are used in these areas as well as the processes that underlie appropriate application of terms and concepts to a variety of problems. In this regard, simulations offer a heuristic advantage over traditional methods (2). Therefore, it appeared that judicious ap-

plication of simulation materials could be useful.

The first step in deciding how simulations would be integrated into each of these course programs involved a careful assessment of both the strong and weak points of the traditional methods that had been used previously. Second, a search was made for simulation materials that could be used to address the identified areas of weakness. Third, each course was restructured to include the use of simulation activities as an integral, ongoing course component in a manner complementary to the traditional activities that were retained. A description of how these procedures were implemented in undergraduate courses in physiological psychology and statistics and design is presented in the remainder of this paper.

I. Simulations in physiological psychology.

In evaluating students' accomplishments in this course, three areas of weakness were identified. First, while students were quite adept at describing the structures of models of central nervous system processes described in their texts and in lectures, they were often unable to predict the consequences of operation of these models. Second, while students could master the principles necessary to understand one topic area, they often failed to see that the same or similar principles were involved in accounting for other areas of behavior. Third, students often stopped short of recognizing the ramifications of changes in one part of the nervous system for other aspects of nervous system functioning, and for a variety of behaviors.

Computer simulations appeared to provide an excellent vehicle

for characterizing nervous system functioning in a manner that would address all three points.

First, the execution of complex but interactive procedures through a computer program provides a reasonable representation of processes that characterize nervous system operation. By providing an example of a model in operation, students may explore the consequences of a variety of nervous system activities in a realistic way. Second, by examining models developed for different topics, students would clearly see the similarities in the principles that govern their operation, and thus move towards generalizing this knowledge to a wider variety of topics. Third, by examining appropriately-constructed simulations, the student would be presented with a diversity of outputs representative of the multiple ramifications of changes in activity in a given part of the nervous system.

After this analysis of the manner in which computer simulations could enhance learning was made, a search was made for computer simulations that could be used to accomplish these objectives. Unfortunately, available simulations were either too detailed to be appropriate for this course (13) or lacked the illustration of processes that was desired (5). Therefore, it was necessary to develop simulations specifically designed to meet the objectives described above.

Two computer simulations have been completed to date. NEURON presents a simple model nervous system and operates on the principles of spatial summation, temporal summation, recurrent collateral inhibition, and presynaptic inhibition. This simulation gives students an opportun-

ity to examine the manner in which these principles determine the flow of information through the nervous system. Generally, the student may choose values for three input parameters: where activity is initiated, how long neural activity lasts at the starting neurons, and the rate of firing of the starting neurons. The simulation outputs the total activity shown by each neuron. The student then must explain why each output occurred based on the principles by which the simulation operates.

PAIN is based on the Melzack and Casey (6) model of pain perception. This simulation allows the student to examine stimulus and context characteristics that determine whether or not a given event will be perceived as painful. The principles that govern execution of this model are essentially identical to those employed in the NEURON simulation. The student may examine this model by using stimuli and contexts that are contained within the simulation, or the student may define new stimuli and contexts by selecting a set of input parameters on his own. This simulation allows the student to easily examine critical parts of the model as well as to examine the model in its entirety; the outputs focus on both the physiological changes occuring within the nervous system and the behaviors which would result from these processes. Thus, this simulation allows the student to develop a better understanding of the relationship between physiological and behavioral events.

In addition to the actual computer simulations, a handout to accompany each simulation was developed. The handouts provide the necessary link between the computer simulations and the material presented in the course readings and in the classroom. The handouts describe the problem

being simulated, how the simulation operates, and how the simulation is to be used. They do not serve as a substitute for the reading and classroom discussion that is expected of the student. Rather, the problems presented in each handout encourage the synthesis of the simulation work with the other work being done for this course.

The simulation work was included as part of the regular assignments described in the course syllabus. As different topics were presented in class, students were expected to answer the questions provided in the handout as part of their normal out-of-class work. The simulation problems thus also provided additional examples that were used to facilitate class discussion (11).

II. Simulations for statistics and design.

An evaluation of this course clearly pointed to the benefits of treating statistical and design issues in an integrated fashion. The context in which statistics are appropriately applied becomes clearer, and the use of statistics in dealing with some aspects of experimental design problems is readily apparent. Several areas of weakness were apparent in this regard, however. While students could usually master the use of a particular statistical test when simply presented with a set of data, it was difficult to provide a context in which students could learn to apply statistical tests appropriately to actual research problems. This problem is related to the relatively poor quality of the examples and problems that must be relied on in a traditional approach to the teaching of this course. Examples of "average" difficulty are needed because of disparities in students' rates of mastery over this

type of material. In addition, it is necessary to use examples that have solutions that can be described rather quickly, usually demanding no more time than a single class period. These examples as well as the data presented for analysis are necessarily contrived, since time constraints demand that one example serve to illustrate several points. In addition, too few and not enough variety in examples and problems are provided, again due to time constraints. It is clear from exam performance that students must be exposed to a variety of problems in order to develop facility with this type of material and to discover precisely where his or her problems in dealing with this material lay. A related problem focuses on the ability of students to appreciate the variety of design and statistical techniques that may be applied in pursuing a research problem over an extended period of time. A general lack of sophistication was apparent in recognizing the theoretical consequences of developing a particular research strategy as well as the limitations that are imposed on the inferential process by the particular analytic techniques selected for use. Finally, students' inability to deal with actual research problems encountered in subsequent laboratory courses also pointed to the need for more realistic examples and problems for practice in this course.

In general, then, a clear need was apparent for materials which employed a set of realistic problems that students could investigate in a self-paced manner. Ideally, such materials should include problems for which different experimental approaches could be formulated by the student, problems which could be investigated over a relatively long time

period, and a method for generating realistic data for student-designed experiments which could be used for developing expertise in statistical analysis.

Statistical packages such as SPSS (7) were rejected since there appeared to be little opportunity for using them to examine both design - and statistic:-related problems. Instead, a package of computer simulations called WRIST (Wabash Research Investigation Simulation Teacher) was selected. This package is one of several versions of EXPER SIM (5). It consists of interactive computer simulations designed to allow students to investigate psychological problems of current interest. The package includes a workbook describing each simulation and the research on which each is based, as well as the computer programs needed to use the simulations (8, 10).

For each simulation in the package several variables which have been shown to affect behavior are described. For example, in the problem area of obesity, variables which affect eating behavior are included. By selecting certain variables for input to the simulation, the student designs an experiment to test the effects each has on eating behavior. When the computer receives this input, output is generated which consists of the number of grams of food eaten by each subject tested under each of the designated experimental variables. The student then may analyze these data using statistical techniques to arrive at a conclusion about how each experimental variable may contribute to obesity.

This type of package meets the objectives states for course improvement in the following ways. First, since the data used for statistical

analysis follow directly from the student-formulated experimental design, the student sees how both design and statistical factors contribute simultaneously to his investigation of the problem. Second, since many variables may be manipulated, the student may design simple or complex experiments, appropriate to his own level of competence with design techniques. Third, the many possibilities for experiments in each problem area allow the student to develop a long-term research program which may allow him to compare the usefulness of several different types of designs and statistical analyses in addressing particular issues.

To integrate this simulation package into the general course program, an extensive study program was developed. This study program is based on a series of problems which focus on the use of the techniques being discussed in the classroom. Three general types of problems are included. One type consists of descriptions of poorly-designed experiments, that is, experiments which violate the principles being discussed in class. The student must identify the design faults, and redesign the experiment to correct these faults. The second type of problem consists of a description of a specific issue for which the student must formulate a sound experimental approach. The simulation package is then used to "execute" the students' design and provide data which can be used to help formulate a statement about the issue under investigation. The third type of problem focuses on statistical analysis: selection of appropriate statistical tests, execution of the test, and interpretation of the results based concurrently on statistical and design considerations.

The problems in the study program were assigned as homework on the

course syllabus. This allowed the student to apply the concepts being discussed in class to the simulation problems. While due dates for this homework were provided, the students understood that the "deadlines" were merely guidelines to help them pace their work. As students turned in their homework, their work was evaluated and returned to them. If their work was not correct in some way, they continued to work on the problem until a satisfactory solution was reached. This allowed each student to develop facility in the use of design and analytic techniques at a rate suited to his abilities (12).

III. Summary and conclusions.

It should be clear from the preceding discussion that different types of needs were identified for each of these courses. In the physiological psychology course, the primary purpose of simulation activities was to provide a means by which students could examine processes and learn to predict the outcome of active processing in a system. In the statistics and design course, the primary purpose of simulation activities was to provide a problem and data set which could be used to practice skills and concepts presented through more traditional approaches. While other types of simulations were available for use in both of these courses, they were not employed, since no clear objectives for their use had been identified. This allowed retention of many of the traditional course activites that were seen as important for transmitting certain types of information, but also addressed specific areas of weakness in an attempt to improve the overall quality of each course.

Formal evaluation of the use of simulations as integrated course

activities to complement more traditional educational methods is currently under way. Although this evaluation is still in a preliminary stage, some benefits derived from this approach are already apparent. First, computer simulations have served a time-saving function in both of these classes. Considerably less class time has been needed to work through models and to present examples compared to that spent in previous semesters. Students use the simulations outside of class to engage in these activities and come to class prepared to participate in more analytic, in-depth discussion of concepts and their application. Class time is then spent more productively by discussing some of the more complex aspects of different problems and pointing out the benefits and drawbacks to various approaches one might take in the direct application of concepts to research problems. This has produced a higher quality of classroom interaction and thus served to enhance the benefits that students derive from more traditional classroom activities. Second, students have indicated greater course satisfaction than in previous semesters. While this may be attributed in part to the simple improvement in instruction that one gains with each semester's experience, the use of simulations as part of the course activities has been singled out by students as a particular feature of the course that they felt was beneficial to their learning experience. Finally, in the statistics and design course, some students have used the simulations as a starting point for research they planned to engage in after the course ended. Thus, the simulations have served as vehicle for promoting continued interest in the subject matter under study and provided a concrete

means by by which students could easily make a transition from one focus of study to another. Since this type of endeavor had not developed from the statistics and design course in the past, it is felt that simulations have added an important and valuable dimension to this course.

The primary purpose of this paper has been to provide examples of different ways that simulation activities may be included in an undergraduate course curriculum. It appears that simulations may provide educational benefits not readily obtained from more traditional activities without radical transformations in course structures. While an evaluation of this more limited use of simulation activities is not yet complete, preliminary indications point to the potential value of this type of approach.

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